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ABSTRACT

This paper argues that Merrill's instructional transaction theory provides a framework that can decrease learners' problems in using computer simulations by specifying transaction shells rather than frames in designing interactive courseware. The three types of data used in a transaction, i.e., an instructional algorithm, are identified as a knowledge base, a resource database, and a set of instructional parameters. Each of these types of data is described in detail: (1) the knowledge base consists of three types of frames (entities, activities, and processes), and a number of elaborations of these frames (attributes, components, abstractions, and associations); (2) the resource database contains mediated representations of the domain knowledge together with presentation techniques to display the results of the model, acceptance techniques to make interventions in the model possible, and communication techniques to transfer data from the model to the educational representation and back; and (3) instructional parameters can be designed for a particular population, learning task, and environmental situation. The value of instructional transaction theory for computer simulations is specified as the definition of domain knowledge to include in the simulation and the separation of the instructional parameters. Examples of instructional parameters are given, and it is noted that further research and development are needed to identify the instructional parameters and the domain knowledge to include in a "process" transaction shell. (Contains 8 references.) (ALF)

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INSTRUCTIONAL TRANSACTION THEORY APPLIED TO COMPUTER SIMULATIONS

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Computer simulation has great potential for use in education. However its greatest advantage (freedom for the learner to interact with a model of reality) can turn into a disadvantage that makes it ineffective in terms of learning outcome. Students need to have a high prior knowledge to understand what they can do in the simulation environment, students might develop misconceptions (Burton & Brown, 1982) and the instructional environment isn't able to correct them, 'learning by doing' with simulations can be time-consuming and working with computer simulations can lead to fragmented knowledge of a system (Min, 1987).

The instructional transaction theory of Merrill (Merrill, 1991) provides an useful framework to decrease problems in the use of computer simulations. This theory describes the use of transaction shells to design interactive, not frame-based, courseware. It is based on the concept of a instructional transaction which is "the complete sequence of presentations and reactions to acquire a specific type of instructional goal" (Merrill, Li and Jones, 1991).

A transaction is an instructional algorithm. It uses three type of data:

- 1 a knowledge base
- 2 a resource database.
- 3 a set of instructional parameters

Knowledge base

The knowledge base consists of frames. The instructional transaction theory describes three types of frames (entities, activities and processes) and a number of elaborations of these frames (attributes, components, abstractions and associations). Applied to computer simulations the knowledge base should include frames for the system as a whole, for every entity in the system and for the relations between these entities. Beside this an executable model of the system is necessary. Most of the time this is a mathematical representation of the process. The knowledge base can be called a conceptual model of the domain, the executable model a runnable model (van Joolingen & de Jong, 1991)

Resource database

The resource database contains mediated representations of the domain knowledge. Specific for simulations the resource database holds techniques for *presentation, acceptance and communication* (Min, 1987). To use the knowledge in the (runnable) model for educational purposes the resource database contains presentation techniques to display the results of the model, acceptance techniques to make interventions in the model possible and communication techniques to transfer data from the model to the educational representation and back.

Instructional parameters

By configuring the instructional parameters of a transaction shell instruction can be designed for a particular population, learning task and environmental situation.

The instructional parameters tune a simulation to the needs of specific learners, specific goals and learning strategy by defining

- the interventions,
- the output and the
- learning process.

The interventions can differ in number and type (e.g. choice out of alternatives vs. free, intervention only before simulation vs. changes during simulation) of interventions.

The representation of results can differ in which output-variables of the model to display and the way this representation is done.

The learning process can be free discovery learning, guided discovery learning, problem solving or scientific experimentation. Dependent on the chosen learning process the

instructional designer needs to specify the guidance, the problems to present to the learner etc.

The value of the instructional transaction theory for computer simulations is twofold:

- 1 the definition of domain knowledge to include in the simulation
- 2 the separation of the instructional parameters.

Ad 1

'Traditional' computer simulations focus on the relations between entities in a system. The representation of domain knowledge in a frame network makes clear that a mental model of a systems consist of more elements than the relations between entities.

Ad 2

The instructional parameters are usually set within the simulation itself, thus being an 'implicit' instruction strategy (Duffy & Jonassen, 1991). The separation of the instructional parameters makes this strategy 'explicit' thus offering possibilities to change it. This can lead to adaptive simulations (changes in the parameters during execution) and possibilities to re-use simulations in different educational settings (by changing the parameters in a preparation phase).

In the project "Instructional Design of an Optical DataBase (ODB)" at the University of Twente the Instructional Transaction Theory is applied.

The main objective of the ODB-project is to develop the didactics (instructional principles) for the use of multimedia databases for multiple educational targets. Within the Database dynamic objects (simulations) are incorporated. The simulations can make use of the other parts of the DataBase like audio and video fragments, animations, questions and explanations.

The multiple use of simulations is encouraged by providing teachers the possibility to manipulate instructional parameters of the simulation. Doing this the teacher can adapt the simulation to his audience and his instructional goals.

From the simulation the learner can have access to other parts of the database including instruction in unknown concepts involved in the simulation and an encyclopedic system.

The current research focuses on the necessary elements to included in the domain knowledge representation and the identification and implementation of *instructional parameters* that influence the successful use of simulation in education.

For this purpose a 'process' transaction shell is being developed. Every educational computer simulation is a specific instance of this transaction shell based on a specific model, with specific in- and output possibilities and specific instructional events to facilitate learning. By instantiating this class with specific instructional parameters in the context of a multimedia database it is expected that the instructional effectiveness of simulations can be improved.

Examples of Instructional parameters

Every transaction shell has it's own set of parameters. A set of parameters must be based on (empirical) research. In the work of Merrill parameters for the 'identify' transaction shell are given as an example (Merrill, 1991). The 'process' transaction shell has it's own set. The following parameters are examples of the parameters for this transaction shell. Described are the name of the parameter, the possible values and the way the influence the transaction.

Output mode

The output mode parameter describes the way results of the model are presented to the learner. Possible values are enactive, iconic or symbolic (Bruner, 1966).

As an example the output of a simulation of the renneting of milk is used:

Value	Output
Enactive	A sequence of video-segments showing a person checking the viscosity of the milk
Iconic	A graph of the viscosity of the milk against time
Symbolic	A column of the exact value of the viscosity at different moments in time

Example 1: values of the output mode parameter

Order of the presentation

The 'order of the presentation' parameter describes the form in which relations are shown to the user. The values are zero-order, first order and quantitative (White & Frederiksen, 1989). As an example the amount of enzyme in milk during pasteurisation is used.

Value	Output
Zero	The presence or absence of the enzyme is shown
First	The change in the amount of enzyme is shown
Quantitative	The exact value of the amount of enzyme is shown

Example 2: values of the 'order of the presentation' parameter.

Conclusion

The Instructional Transaction Theory can be applied to computer simulations. Research and development is necessary to identify the instructional parameters and the domain knowledge to include in a 'process' transaction shell.

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